

# **Health & Safety Manual**

## **Supplement 24.15**

### **Electrical Instruments for Use With Explosives Systems**

**September 1994**

**Approved by the ES&H Working Group**

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# **Electrical Instruments for Use With Explosives Systems\***

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# **Electrical Instruments for Use With Explosives Systems**

## **1.0 Introduction**

### **1.1 Purpose and Scope**

Electrical instruments are frequently used at LLNL to analyze and verify the continuity of electrical circuits associated with explosives systems. These instruments are controlled, and when used properly they cannot cause damage to or initiate a reaction in explosives systems.

This supplement governs the use of electrical instruments at Site 200 (Livermore main site) and Site 300; serves as a basis for developing procedures for such instruments at the Nevada Test Site (NTS); and describes the review process, the classification process, and certification and control requirements for instruments used on explosives systems. Appendix A lists the instruments certified and approved for use on explosives systems.

### **1.2 Definitions**

Below are terms and definitions used in this supplement.

approval	Formal documentation authorizing the use of certified test instruments.
calibration	The process of standardizing the ability of the test instrument to measure to an accepted value.
certification	Formal documentation certifying that the test instrument has fulfilled the specific acceptance requirements.
high-energy device	An electroexplosive device (EED) that requires the discharge of high current through the device bridgewire or foil, or other similar device, to initiate the device and produce a shock wave.
low-energy device	All EEDs except exploding bridgewire (EBW) or exploding foil (slapper) detonators, or similar high-energy devices. These devices can be initiated by a low current.
qualification	The process that a test instrument must go through to ensure compliance with specific acceptance requirements.

## **2.0 Applicability**

The requirements in this supplement are applicable to the use of electrical instruments on explosives systems at LLNL and Site 300. They also serve as a basis for developing procedures for such instruments at the Nevada Test Site (NTS).

## **3.0 Requirements/Regulatory Summary**

Chapter II, Section 13.8.2 (“Certification”), of the Department of Energy (DOE) *Explosives Safety Manual* requires all DOE facilities to establish a formal system to review and certify electrical test instruments used on explosives systems. Instruments used on nuclear explosive assemblies shall comply with DOE Order 5610.11, Chapter VII, “Nuclear Explosive Safety.”

## **4.0 Process for Compliance**

### **4.1 Explosives Systems**

Chapter II, Section 13.8.1 (“Classification”), of the DOE *Explosives Safety Manual* requires the establishment of instrument categories so that each instrument type (Types I, II, and III) can be applied safely to one or more of the classes for explosives systems. See Section 4.2 in this supplement for a complete description of the instrument types.

#### **4.1.1 Initiating Systems**

*Low-energy or hot-wire-initiating systems*—Electrical circuits connected to any EED (e.g., a hot-wire actuator, blasting cap, squib, an ignitor, or a similar low-energy device designed to initiate the explosive) that can be initiated by low energy.

*High-energy-initiating systems*—Electrical circuits connected to any EED (e.g., an EBW detonator, exploding foil (slapper) detonator, or a similar high-energy device designed to initiate the explosive) that can be initiated by high energy.

#### **4.1.2 Non-initiating Systems**

*Non-initiating systems*—Electrical circuits that are attached or adjacent to any explosive material but are not designed to initiate the explosive. These circuits are connected to sensitive control systems; mechanical systems; or auxiliary circuits used with explosives or device components (e.g., circuits connected to arming and firing system component circuits, strain gages, pin switches, pressure transducers, thermocouples, or equivalent systems).

## 4.2 Instrument Classification and Identification

Instruments are classified into three types (Types I, II, and III) based on the electrical characteristics that affect the safe use of those instruments on explosives systems. Color-coded labels are assigned to each instrument type for ease of recognition. At LLNL, these labels shall only be applied to instruments that have been approved by the High Explosives Instrument Committee (HEIC) and shall have the corresponding electrical characteristics.

All test instruments classified as Type I, II, or III shall be specifically approved and meet the design criteria in Section 4.3. Instruments that do not meet these criteria may be used on explosives systems only if (1) management determines the activity is a remote operation, and (2) adequate shielding or sufficient distance is provided. The control, maintenance, and calibration requirements for non-approved instruments shall be specified in an FSP or OSP. The OSP shall be posted on or near each instrument or shall be available in the area where the instrument is used.

**Type I Instruments**—Instruments designed for use on low-energy or hot-wire initiating systems. The maximum design short-circuit current for Type I instruments is less than 10 mA; the label for these instruments is color-coded green with silver letters (see Fig. 1).



**Figure 1. Label for Type I instruments—color-coded green with silver lettering.**

**Type II Instruments**—Instruments designed for use on high-energy initiating systems. The maximum design short-circuit current for Type II instruments is less than 100 mA; the label for these instruments is color-coded green with red stripes (see Fig. 2).

**Type III Instruments**—Special-use instruments used on non-initiating systems. These instruments shall meet the electrical requirements for the explosive work area where used, and shall be approved by the HEIC for the specific application intended. The maximum design short-circuit current for Type III instruments may exceed that of Type II; the label for these instruments is color-coded red with silver letters (see Fig. 3).



**Figure 2. Label for Type II instruments—color-coded green with red stripes.**



**Figure 3. Label for Type III instruments—color-coded red with silver lettering.**

### 4.3 Instrument Design Criteria

To gain approval as a Type I, II, or III instrument for use on explosives systems, all instruments shall (1) meet the general design criteria below; (2) be current-limited; and (3) have their wiring diagrams and internal circuitry design analyzed, examined, and certified before approval (see Section 4.4).

- The cases for Types I, II, and III instruments shall be dust-resistant. Fixed instruments located in control rooms are exempt from this requirement.
- The current-limiting features of an instrument shall be internal to the test instrument, and shall not be dependent upon a fuse or the test circuit-load characteristics.
- Batteries supplying power to any instrument shall be of minimal voltage; they shall not be higher than the amount necessary to perform the tests.
- An instrument shall not have, within itself, enough energy or combustible material to produce a fire if that instrument malfunctions. Self-extinguishing or non-combustible materials must be used wherever possible.
- The output current, through a resistance equivalent to that of the minimum resistance initiator of the explosives system class, should not exceed 1% and shall not exceed 10% of the no-fire rating for the most sensitive initiator of the class. For example, Type I instruments are limited to a maximum short-circuit current output of 10 mA; Type II instruments are limited to 100 mA. The calibration of currents will be verified with calibrated test instruments traceable to the National Institute of Standards and Technology (NIST) and certified by DOE contractor personnel in accordance with standards established by a DOE-contractor-controlled calibration laboratory. *This requirement cannot be delegated to a non-DOE-contractor-controlled calibration laboratory.*
- Instruments shall be designed such that a single component failure will not allow available current from the terminals to exceed the maximum design limit of the short-circuit current for the instrument's classification. For example, the internal circuitry shall be designed to include isolation features that require two independent failure modes (as a minimum) before the specified output current can be exceeded. New, revised, or functionally modified Type I and Type II instruments shall undergo a comprehensive failure analysis to meet this design requirement. Type III instruments shall be reviewed by the HEIC before approval for a specific use.
- Where possible, a comprehensive (point-to-point) check should be made to ensure the electrical wiring corresponds to the wiring diagram, and that all components function properly and within specifications.
- Types I and II instruments shall be designed such that their available short-circuit current can be verified before each use. These instruments shall be

battery-powered, and their test connections shall be verifiably incapacitated during any battery-charging operation.

#### **4.4 Qualification and Approval of Instruments**

The procedure for qualifying, certifying, and approving instruments for use with explosives systems is as follows:

1. The intended user submits the following to the HEIC at least two months in advance of the use date:
  - The commercial model or prototype of the instrument
  - A complete set of drawings
  - The electrical specifications
  - Test data
  - Other pertinent information about the instrument
2. The HEIC does the following:
  - Arranges for a failure analysis to be performed if the instrument requires Type I or II qualification.
  - Instructs the Electronics Engineering Department (or its designee) to inspect and test the instrument to meet the requirements described in this supplement.
  - Reviews and approves the instrument and test data.
3. The Electronics Engineering Department (or its designee) develops a written calibration/certification procedure and a calibration data report for the instrument. The procedure is structured so that work can be reproducible. Automated test procedures are *not* authorized.
4. The HEIC approves the certification/calibration procedure in accordance with the facility procedures for the Electronics Engineering Department.
5. The HEIC chairperson generates a memorandum approving the new instrument as either Type I, II, or III. He/she then notifies the chairperson of the DOE Explosives Safety Committee (ESC) in writing of the approval of instruments for use with initiating systems (see Chapter II, Section 13.8.2.d of the *DOE Explosives Safety Manual*). The HEIC chairperson then informs other DOE contractor organizations of instrument approvals. The LLNL representative of the DOE ESC notifies the HEIC in writing of instruments qualified by other DOE contractor organizations.



## 4.5 Instrument Verification and Use

To demonstrate continued safe use while in service, the instrument's current output must be checked frequently. In addition, all instruments used on initiating systems shall have their current-limiting features verified before each use. Only approved and certified instruments shall be used to verify the output current of instruments used on initiating systems. If any instrument exceeds  $\pm 5\%$  of the expected value, that instrument shall be withdrawn from service and returned to the Electronics Engineering Department for repair and recertification.

If the application so requires, Type I instruments may be used in lieu of Type II or Type III, and Type II instruments in lieu of Type III. Under no circumstances shall Type II or Type III instruments be used as Type I, nor shall Type III instruments be used as Type II unless the operation is conducted remotely and is covered by the FSP or an OSP.

## 4.6 Instrument Controls

All certified instruments shall be kept under strict administrative control to prevent misuse. In addition, Type III instruments used on non-initiating systems shall meet the following requirements:

- New, revised, or functionally modified Type III instruments must be thoroughly reviewed by the HEIC before approval for specific use. *These instruments shall not be released to the user without an approved FSP or OSP.*
- All uses of Type III instruments shall be analyzed to ensure that their normal test energy will not ignite the explosives in the system during the test.
- If the instruments are used to measure sensors directly applied to explosives systems (e.g., bonded strain gauges or pin switches), they shall meet the output current limitations described in Section 4.3.
- Because many Type III instruments do not meet the requirements for initiating systems, all restrictions shall be prominently affixed to the instruments.

The term "remote use only" shall be prominently displayed on instruments approved for specific use, including a reference to the FSP or OSP that controls their use. Also, restrictions shall be prominently affixed to instruments used on non-initiating electrical systems to prevent misuse.

NOTE: Personnel using any electrical instrument on explosives systems shall consider the effect the instrument's output may have on that system and determine if additional controls (e.g., remote operation) may be necessary.

## **5.0 Responsibilities**

### **5.1 High Explosives Instrument Committee**

The HEIC is appointed by the Deputy Associate Directors for the Electronics Engineering and the Mechanical Engineering Departments. The Committee is made up of personnel from the Electronics Engineering Department, the Mechanical Engineering Department, and the Hazards Control Department who are knowledgeable in specific areas of electrical instruments used in explosives operations. The HEIC is responsible for

- Reviewing electrical instruments proposed for use on explosives systems.
- Approving electrical instruments that meet specified requirements.
- Establishing a formal system for controlling all instruments used on explosives systems.
- Defining calibration and certification requirements for approved electrical instruments.
- Reviewing and approving the individual instrument operating procedures.
- Recommending additions or changes to the instrument control system when appropriate.
- Reviewing this supplement annually and initiating revisions as needed.

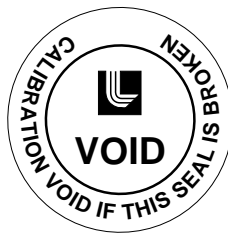
The HEIC chairperson is responsible for ensuring that the appropriate documentation for any HEIC action is completed.

### **5.2 Electronics Engineering Department**


The Deputy Associate Director for the Electronics Engineering Department (or his/her designee) is responsible for appointing members to the HEIC and for ensuring that a formal program exists within the Department for the following:

- Cataloguing, labeling, color-coding, and certifying electrical instruments in accordance with this supplement.
- Testing, repairing, and calibrating electrical instruments used on explosives systems in accordance with instrument-specific procedures.
- Maintaining failure analysis and service records for all instruments approved by the HEIC for use on explosives systems. Records shall be maintained for the life of all instruments certified.

- Affixing a tamper-resistant seal (Fig. 4) to instruments to ensure their internal integrity and a “Notice of Certification” label (Fig. 5) to certify their electrical performance and the calibration date. The calibration date should be no longer than one year from the date of certification. Instruments whose calibration date has expired shall not be used on explosives systems. *Removal or defacement of either the tamper-resistant seal or the “Notice of Certification” label shall be cause for immediate return of an instrument to the shop for recertification.*
- Ensuring that approved instrument-specific operating procedures are with each instrument before leaving the instrument calibration shop.



**Figure 4. Tamper-resistant seal.**

LAWRENCE LIVERMORE NATIONAL LABORATORY		
HIGH EXPLOSIVE INSTRUMENT		
TYPE _____	MODEL _____	I.D. NO. _____
VOLTAGE, OPEN CIRCUIT _____		VOLTS
CURRENT (.02Ω) _____	CURRENT (0.5Ω) _____	
DATE CERTIFIED _____	INST. SHOP TECH. _____	
CALIBRATION EXPIRATION DATE _____		
NOTICE OF CERTIFICATION		

**Figure 5. Notice of Certification label.**

### **5.3 Mechanical Engineering Department**

The Deputy Associate Director for the Mechanical Engineering Department (or his/her designee) is responsible for appointing members to the HEIC.

### **5.4 Supervisors**

Supervisors are responsible for the following:

- Ensuring that personnel operating test instruments with explosives systems are properly trained and qualified to use those instruments. To be qualified, employees must be able to demonstrate to their supervisors the proper use of each instrument and show an understanding of the differences between explosives systems. All training must be documented in the employee's Training Qualification Record (Form RL-2999-9) or equivalent.
- Evaluating all proposed use of test instruments to ensure that they are appropriate for the application.

### **5.5 Users**

Individuals who use electrical instruments with explosives systems are responsible for the following:

- Evaluating the proposed use of the test instruments and for ensuring that their capability and qualifications are appropriate for the application.
- Ensuring that electrical instruments are certified and calibrated, and that all labels and seals are in place.
- Providing an account number to which the costs associated with instrument qualification and approval can be charged.
- Following instrument-specific operating procedures attached to or included with each instrument.
- Using the instrument appropriately. This includes understanding all aspects of the instrument and the consequences of substituting the different types of instruments. Special conditions for use as stated in the FSP or OSP must be followed.

## Appendix A

### Approved Instruments\*

Below is a list of approved electrical test instruments and their specific uses with explosives systems.

Instrument	Type	Specific use
Fluke 8012A/AD (Sandia SE-3065)	I	Ohmmeter used on initiating and non-initiating circuits
Fluke 8025A	III	Testing the Fluke 8012A/AD
LEA 83-1838-01	III	Strain gage power supply used on non-initiating circuits
Sandia PT-4030	III	Ohmmeter used with noninitiating circuits

\* Only individual instruments designed, tested, and certified as outlined in this supplement are approved for use with explosives systems in a non-remote operation.